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Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Original) A transcoding apparatus between code-excited linear prediction (CELP)-based codecs using bandwidth extension, the apparatus comprising:

a formant parameter converter which extracts formant parameters from an input narrowband bitstream, and converts the extracted formant parameters into formant parameters in an output wideband CELP format;

an excitation signal parameter converter which converts excitation signal parameters from an input narrowband bitstream, into excitation signal parameters in an output wideband CELP format; and

a quantizer which quantizes the wideband CELP format formant parameters converted in the formant parameter converter and the wideband CELP format excitation signal parameter converted in the excitation signal parameter converter, respectively in an output CELP format.

2. (Original) The apparatus of claim 1, wherein the formant parameter converter comprises:

a formant bandwidth extender which extracts formant parameters from an input narrow band bitstream, and extends the bandwidth of the extracted narrowband CELP format formant parameters, from a narrowband to a wideband;

a formant order converter which converts the order of the bandwidth-extended formant parameters, into the order of an output CELP format; and

a formant frame rate converter which adjusts the frame rate of the order-converted formant parameters in order to fit the frame rate of the output CELP format, and provides the frame rate converted formant parameters to the quantizer.

3. (Original) The apparatus of claim 1, wherein the formant parameter converter comprises:

a 1st formant type converter which extracts formant parameters from an input

narrowband bitstream, and converts a type of the extracted formant parameters in the narrowband CELP format into type a type suitable for formant bandwidth extension;

a formant bandwidth extender which extends the bandwidth of narrowband parameters whose type is converted in the 1st formant type converter, from a narrowband to a wideband;

a 2nd formant type converter which converts the type of the bandwidth-extended formant parameters, into a formant type suitable for order conversion;

a formant order converter which converts the order of the formant parameters whose type is converted in the 2nd formant type converter, into the order of the output CELP format;

a 3rd formant type converter which converts the type of the order-converted formant parameter, into a formant type appropriate to frame rate conversion;

a formant frame rate converter which adjusts the frame rate of the formant parameters whose type is converted in the 3rd formant type converter, to fit the frame rate of the output CELP format; and

a 4th formant type converter which converts the type of the frame rate converted formant parameter, into a formant type for quantization in the output CELP format, and provides the converted formant coefficients to the quantizer.

4. (Original) The apparatus of claim 3, wherein the 1st formant type converter converts a type of the extracted formant parameters in the narrowband CELP format, into a line spectral frequency (LSF) type.

5. (Original) The apparatus of claim 3, wherein the 2nd formant type converter converts the type of the formant parameters whose bandwidth is extended to the wideband, into a reflection coefficient type.

6. (Original) The apparatus of claim 3, wherein the 3rd formant type converter converts the type of the formant parameters whose order is adjusted, into a line spectral pair (LSP) type.

7. (Previously Presented) The apparatus of claim 1 or claim 2, wherein the formant bandwidth extender comprises:

a formant coefficient scaling unit which scales the received narrowband formant coefficients to extend the bandwidth in a formant parameter domain, and obtains formant coefficients corresponding to a low band part of an overall wideband formant coefficients wherein the scaling factor can be determined by a ratio of bandwidth in an input narrowband CELP format and bandwidth in an output wideband CELP format;

a narrowband codebook searching unit which by using the received narrowband formant coefficient and referring to a narrowband codebook trained in advance, finds an index of a closest codeword;

a wideband codebook searching unit which by referring to an wideband codebook trained in advance, searches for a wideband codeword corresponding to the index of the narrowband codeword searched by the narrowband codebook searching unit;

a codeword truncation unit which truncates the wideband codeword searched in the wideband codebook searching unit so that only a component corresponding to the high band of the wideband remains;

a formant coefficient concatenation unit which adds the low band formant coefficients obtained in the formant coefficient scaling unit and the high band formant coefficients obtained in the codeword truncation unit and generates bandwidth extended wideband formant coefficients; and

a codeword training unit which generates the narrowband codebook and the wideband codebook through training.

8. (Original) The apparatus of claim 7, wherein the codeword training unit comprises:

a wideband voice database which stores wideband voice samples;

a sampling frequency conversion unit which generates narrowband voice samples through the sampling frequency conversion of the wideband voice samples;

a narrowband voice database which stores narrowband voice samples generated by the sampling frequency conversion unit;

a 1st linear predictive coding analysis unit which generates LPC coefficients through linear predictive coding analysis method used in a narrowband CELP codec for the narrowband voice database, and a 2nd linear predictive coding analysis unit which generates LPC coefficients

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through linear predictive coding analysis method used in a wideband CELP codec for the wideband voice database;

a 1st coefficient type conversion unit which generates the narrowband formant coefficients by converting a type of the LPC coefficients generated in the 1st linear predictive coding analysis unit, into a formant coefficient type appropriate to training, and a 2nd coefficient type conversion unit which generates the wideband formant coefficients by converting the type of the LPC coefficients generated in the 2nd linear predictive coding analysis unit, into formant coefficients type appropriate to training;

a 1st vector quantization unit which trains the narrowband codebook having a desired number of codewords, by quantizing the narrowband formant coefficients vectors; and

a 2nd vector quantization unit which trains the wideband codebook using the class information on each formant coefficients vector generated additionally in the process for training the narrowband codebook.

9. (Original) The apparatus of any one of claims 2 and 3, wherein the formant order converter, if an input order is greater than an output order, decimates the input order to fit the output order, and if an input order is less than an output order, interpolates the input order to fit the output order.

10. (Original) The apparatus of claim 9, wherein in the decimation of the order conversion, the coefficients greater than the output order are replaced by 0 and in the interpolation of order conversion, the same number of 0's as the lacked order are filled.

11. (Original) The apparatus of any one of claims 2 and 3, wherein the formant frame rate converter, if an input frame rate is higher than an output frame rate, decimates the coefficients of the input parameter to fit the output frame rate, and if the input frame rate is lower than the output frame rate, interpolates the coefficients of the input parameter to fit the output frame rate.

12. (Original) The apparatus of claim 11, wherein in the decimation of the frame rate conversion, the decimated formant coefficients are obtained by applying appropriate weighting

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to input formant coefficients of a current frame and those of a previous frame and then adding the weighted coefficients, and in the interpolation of the frame rate conversion, frame rate converted coefficients are obtained by applying appropriate weighting to the input formant coefficients of a current frame and the input formant coefficients of previous frames and summing the weighted coefficients.

13. (Original) The apparatus of claim 1, wherein the excitation signal parameter converter comprises:

an excitation signal synthesizer which extracts excitation signal parameters from an input narrowband bitstream and using the extracted excitation signal parameters, synthesizes a narrowband excitation signal;

an excitation signal bandwidth extender which converts the narrowband excitation signal synthesized in the excitation signal synthesizer, into an excitation signal corresponding to a bandwidth of a output wideband CELP format;

a formant coefficient interpolator which obtains formant coefficients corresponding to a analysis unit of an excitation signal called subframe, by interpolating the formant coefficients converted in the formant parameter converter to the formant coefficients set corresponding to each subframes;

a perceptual weighted filter (PWF) which is constructed using the formant coefficients obtained through interpolation in the formant coefficient interpolator, and, filters the wideband excitation signal from the excitation signal bandwidth extender;

an adaptive codebook searcher which regarding the output signal of the PWF as a target signal, searches an adaptive codebook corresponding to pitch information to fit an output CELP format, calculates the gain of the corresponding codebook, and provides the calculated gain and the searched adaptive codebook index to the quantizer; and

a fixed codebook searcher which, using a target signal of a fixed codebook obtained by subtracting the contribution of the adaptive codebook from the output signal of the PWF, searches for a fixed codebook to fit an output CELP format, calculates the gain of the corresponding codebook, and provides the calculated gain and the searched fixed codebook index to the quantizer.

14. (Original) The apparatus of claim 13, wherein the frame analysis unit of the excitation signal is a subframe unit.

15. (Original) The apparatus of claim 13, further comprising:

a 5th formant type converter which converts a type of the formant coefficients, which are converted into wideband CELP format formant parameters in the formant parameter converter, into a formant coefficient type appropriate to formant coefficient interpolation; and

a 6th formant type converter which converts a type of the formant coefficients, which are obtained in the formant coefficient interpolator through interpolation, into a formant type appropriate to the PWF.

16. (Original) The apparatus of claim 15, wherein the 6th formant type converter converts the interpolated formant coefficient into a linear predictive coding (LPC) coefficient.

17. (Original) The apparatus of claim 13, wherein the excitation signal bandwidth extender comprises:

a sampling frequency conversion unit which converts the narrowband excitation signal sent by the excitation signal synthesizer, into a low band component of wideband excitation signal having a sampling frequency corresponding to a wideband CELP format:

a high band reproducing unit which regenerates an excitation signal component corresponding to the high band of a wideband excitation signal, from the narrowband excitation signal sent by the excitation signal synthesizer;

a high pass filter which extracts only an excitation signal component corresponding to the high band of a wideband, by high pass filtering the excitation signal produced in the high band reproducing unit; and

an adder which generates a overall wideband excitation signal by adding the low band excitation signal generated in the sampling frequency converter and the high band excitation signal generated in the high band pass filter.

18. (Previously Presented) A transcoding method between CELP-based codecs using bandwidth extension, the method comprising:

(a) extracting formant parameters from an input narrowband bitstream, and converting the extracted formant parameters into formant parameters in an output wideband CELP format;

(b) converting excitation signal parameters extracted from an input narrowband bitstream, into excitation signal parameters in an output wideband CELP format; and

(c) quantizing the wideband CELP format formant parameters and the wideband CELP formant excitation signal parameter, respectively, in an output CELP format

wherein the formant parameters and the excitation signal parameters are used to produce digital signals representing a voice to be transmitted.

19. (Original) The method of claim 18, wherein the step (a) comprises:

(a11) extracting formant parameters from a narrowband bitstream, and extending the bandwidth of the extracted narrowband CELP format formant parameters, from a narrowband to a wideband;

(a12) converting the order of the formant parameters, which are bandwidth-extended to a wideband in the step (a11), into the order of an output CELP format; and

(a13) converting the frame rate of the formant parameters, whose order is converted into the order of the output CELP format in the step (a12), in order to fit the frame rate of the output CELP format.

20. (Original) The method of claim 18, wherein the step (a) comprises:

(a21) extracting formant parameters from a narrowband bitstream, and converting a type of the extracted formant parameters in the narrowband CELP format into a type suitable for formant bandwidth extension;

(a22) extending the bandwidth of narrowband parameters whose type is converted in the step (a21), from a narrowband to a wideband;

(a23) converting the type of the formant parameters whose bandwidth is extended to a wideband in the step (a22), into a formant type suitable for order conversion;

(a24) converting the order of the formant parameters whose type is converted in the step

(a23), into the order of the output CELP format;

(a25) converting the type of the formant parameter whose order is converted, into a formant type appropriate to frame rate conversion; (a26) converting the frame rate of the formant parameters whose type is converted in the step (a25), to fit the frame rate of the output CELP format; and

(a27) converting the type of the formant parameter whose frame rate is converted, into a formant type for quantization in the output CELP format.

21. (Original) The method of any one claims 19 and 20, wherein the step for extending the bandwidth of the narrowband formant parameters to a wideband comprises:

(a11_1) scaling the narrowband formant coefficients in the step (a21) to extend the bandwidth in a formant parameter domain, and obtaining formant coefficients corresponding to a low band part of an overall wideband formant coefficients;

(a11_2) by using the narrowband formant coefficients in the step (a21) and referring to a narrowband codebook trained in advance, finding an index of a closest formant coefficients codeword;

(a11_3) by referring to a wideband codebook trained in advance, searching for a wideband formant coefficients codeword corresponding to the index found in the step (a11_2);

(a11_4) truncating the wideband codeword found in the step (a11_3) so that only a component corresponding to the high band of the wideband remains; and

(a11_5) adding the low band formant coefficients obtained in the step (a11_1) and the high band formant coefficients obtained in the step (a11_4) and generating bandwidth extended wideband formant coefficients.

22. (Original) The method of claim 21, wherein the training in the steps (a11_2) and (a11_3) comprises:

(a11_21) generating narrowband voice samples by performing sampling frequency conversion of wideband voice samples stored in a wideband voice database for training, and generating a narrowband voice database for storing these narrowband voice samples;

(a11_22) generating LPC coefficients for the narrowband voice database through linear

predictive coding analysis methods used in narrowband CELP codec and LPC coefficients for the wideband voice database through linear predictive coding analysis methods used in wideband CELP codec, respectively;

(a11_23) generating the narrowband formant coefficients set and the wideband formant coefficients set, by converting the LPC coefficients generated in the step (a11_22), into formant type appropriate to training;

(a11_24) training the narrowband codebook having a desired number of codewords, by quantizing the narrowband formant coefficients vectors generated in the step (a11_23); and

(a11_25) training the wideband codebook using class information on each formant coefficients vectors generated additionally in the process for training the narrowband codebook in the step (a11_24).

23. (Original) The method of any one of claims 19 and 20, wherein the step for converting the formant order comprises:

(a12_1) if an input order is greater than an output order, performing decimation by replacing the coefficients greater than the output order by 0s; and

(a12_2) if an input order is less than an output order, performing interpolation, by filling the same number of 0's as lacked order in order to fit the input order to the output order.

24. (Original) The method of any one of claims 19 and 20, wherein the step for converting the formant frame rate comprises:

(a13_1) if an input frame rate is higher than an output frame rate, decimating the coefficients of the input formant to fit the output frame rate; and

(a13_2) if the input frame rate is lower than the output frame rate, interpolating the coefficients of the input formant to fit the output frame rate, wherein in the decimation of the frame rate conversion, the decimated formant coefficients are obtained by applying appropriate weighting to input formant coefficients of a current frame and those of a previous frame and then adding the weighted coefficients, and in the interpolation of the frame rate conversion, the interpolated formant coefficients are obtained by applying appropriate weighting to the input formant coefficients of a current frame and the input formant coefficients of previous frames and

adding the weighted coefficients.

25. (Original) The method of claim 18, wherein the step (b) comprises:

(b1) extracting excitation signal parameters from a narrowband bitstream and using the extracted excitation signal parameters, synthesizing a narrowband excitation signal;

(b2) converting the narrowband excitation signal synthesized in the step (b1), into an excitation signal corresponding to a bandwidth of a wideband CELP format;

(b3) obtaining formant coefficients for each subframe unit in a analysis unit of an excitation signal, by interpolating the formant coefficients, which are converted into wideband CELP format formant parameters in the step (a);

(b4) converting the formant coefficients obtained through interpolation in the step (b3), into a PWF coefficients corresponding to the output CELP format, and using the PWF constructed from the coefficients, filtering the wideband excitation signal generated in the step (b2);

(b5) with the signal filtered in the step (b4) as a target signal for adaptive codebook search, searching an adaptive codebook corresponding to pitch information to fit an output CELP format, and calculating the gain of the corresponding codebook; and

(b6) by taking the signal generated in the step (b4) subtracting the contribution of the adaptive codebook, as a target signal for fixed codebook search, searching for a fixed codebook to fit an output CELP format, and calculating the gain of the corresponding codebook.

26. (Original) The method of claim 25, further comprising:

(b7) converting the type of the formant coefficients, which are converted into wideband CELP format formant parameters in the step (a), into a coefficient in a type appropriate to formant coefficient interpolation; and

(b8) converting the formant coefficients, which are obtained in the step (b3) through interpolation, into formant coefficients appropriate to the PWF.

27. (Original) The method of claim 25, wherein the step (b2) comprises:

(b2_1) converting the narrowband excitation signal generated in the step (b1) into a low

band of a wideband excitation signal having a sampling frequency corresponding to a wideband CELP format;

(b2_2) regenerating an excitation signal component corresponding to the high band of a wideband excitation signal, from the narrowband excitation signal generated in the step (b1);

(b2_3) extracting only an excitation signal component corresponding to the high band of a wideband excitation signal, by high pass filtering the excitation signal reproduced in the step (b2_2); and

(b2_4) generating a wideband excitation signal by adding the low band excitation signal generated in the step (b2_1) and the high band excitation signal generated in the step (b2_3).

28. (Original) A computer readable medium having embodied thereon a computer program for executing any one method of claims 18 through 27.